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(54) Color variation control method for ink-jet printers.

(57) A method (10) for eliminating visible color variation, or color banding, in areas of the printout that color and black inks are capable of touching, without significant reduction in color-tint printout throughput, are described. The invented method (10) includes detecting or analyzing (14) areas in a print swath defined by a single horizontal pass of the printhead that contain superposed color and black dots. Upon detection of such a condition, the method (10) further includes subdividing the typically broader black swath, e.g forty-eight orifices, into a number of narrower swaths, e.g. by selecting only certain closely vertically adjacent ones of the orifices and their corresponding ink jets, that preferably are of equal vertical height to the height of the corresponding color swath, e.g. sixteen orifices. Printing (16) is performed then--black ink during a first carriage pass followed by color ink during a subsequent carriage pass (20)--by time interleaving one or more of the preferably equal height black and color swaths in such manner that the time between horizontally adjacent black and color ink-jet firing, or dot printing, is substantially constant. Preferably, the method (10) avoids black swath down-sizing or other spatial or temporal accommodations when there is no likelihood of visible color-banding, i.e. when it is determined that there is in the present swath no color and black liquid ink interposition that could result in bleeding.

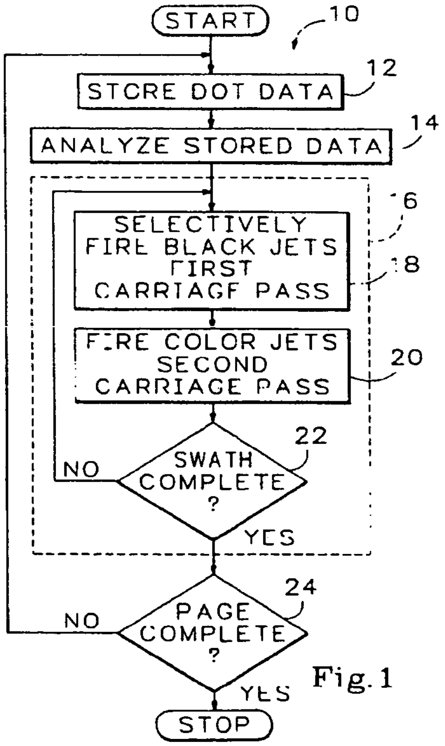

Fig. 1

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head carriage pass, only black ink typically is deposited--as from the black (K) pen--as the corresponding orifice sets are variously labeled in Fig. 2.

It will be seen from Fig. 2 that there are various offsets of the cyan (C), magenta (M) and yellow (Y) pens from the black pen. These are believed to be clearly illustrated by the use of common index numbers in labeling all of the orifices of the various pens. For example, those of the black (K) pen are numbered 1 through 50. Those of the yellow (Y) pen are numbered -3 through 13, with the numbers indicating the relative position of the orifices from correspondingly positioned ones of the black (K) pen having identical numbers and with the numbers -3, -2, -1 indicating positions relative to orifice 1 of the black (K) pen that are shifted upwardly therefrom. Those of the magenta (M) pen are numbered 18 through 33, which again correspond with identically numbered orifices of the black (K) pen. Finally, those of the cyan (C) pen are numbered 38 through 53, with those numbered 38 through 50 corresponding with those identically numbered orifices of the black (K) pen and with the orifices numbered 51, 52, 53 indicating positions relative to orifice 50 of the black (K) pen that are shifted downwardly therefrom.

The dashed outline in Fig. 2 that embraces the black (K) pen orifices numbered 35 through 50 indicates those orifices (or actually their corresponding ink jets not shown) that are used in accordance with the preferred method of the invention during black ink print passes of the ink-jet printers carriage to print a black swath of preferably approximately, more preferably substantially, and most preferably exactly, equal height to the color swath that would be printed by each of the magenta (M), cyan (C) and yellow (Y) pens, which as may be seen from Fig. 2 typically to have vertical arrays of substantially less vertical height.

It is believed to be preferable that the defined black swath height does not vary from the defined color swath height, at least over period of time over which a page of color is printed, by greater than approximately 25%. For example, it has been discovered that greatly improved color printing quality is achieved when the group of vertically adjacent ink jets of the black pen that are fired during a black printhead pass is as high as twenty. While this represents a twenty-five percent greater black swath height than the color swath height defined by all vertically adjacent sixteen ink jets of each of the color pens, nevertheless there is produced no visible color banding, or at least greatly reduced color banding.

It will be appreciated that the black (K) pen might provide more or less vertical resolution than any of the color (CMY) pens. For example, the black pen might have twice the vertical resolution of any of the color (CMY) pens, i.e. the black (K) might have twice the number of vertically arrayed orifices (and corresponding ink jets) as that shown in Fig. 2. Nevertheless, in accordance with the preferred method of the invention as described and claimed herein, the same vertical array of orifices as is represented by the dashed outline (containing twice the number of black orifices) would be used to print a black swath during a single pass of the printhead carriage so that it such black swath height corresponded approximately to the vertical height of a swath defined by a color pen (although the color pen might contain only approximately half as many orifices). Again, it will be appreciated that it is the approximately equal height of the swaths printed during the preferably earlier black print pass of the carriage and the preferably later color print pass thereof that are believed to be important, as opposed to the number of orifices defining such swaths.

It has been determined that depositing black ink drops before depositing juxtaposed color ink drops is an important contributor to the reduction of visible color banding. Thus, the method of the invention by which color banding is reduced may be described alternatively as follows. It may be seen to involve a method of interleaving horizontal black and col r printhead passes to produce tinted color areas including plural instances of horizontally adjacent black and color dots. (It will be appreciated that below a certain number of dots of height in a tinted color area, ther presumably would be color banding, but such might not be visible because of its relatively small scale.)

The invented method may be thought of in the alternative as including performing a black printhead pass to deposit black ink dots, and thereafter performing a color printhead pass to deposit color ink dots that are closely horizontally adjacent such deposited black ink dots. This has been seen to reduce the tendency of the black ink to bleed into the color ink, which tendency is observed to be substantially greater than the tendency of the color ink to bleed into the black ink. Ideally, it is preferred that such earlier black ink deposition be performed sufficiently earli r that the black ink is substantially dry before the color ink is deposited. Nevertheless, and surprisingly, it has been discovered that there is bleeding of black ink into closely adjacent color ink, i.e. where the ink dots barely or nominally touch even tangentially, even after the color ink has substantially completely dried, whereas such is not the case if, as is described herein as being preferred, the black ink is deposited first.

In accordance with the preferred method, such printhead pass-performing steps are controlled, e.g. by the printer's controller, to achieve approximately constant timing between the deposit of such closely horizontally adjacent black and color ink dots, as this is believed also to affect the degree of visible color banding. As suggested abov herein with reference to the fact that the height of the black swath can be as much as 25% greater than the height of the color swath without appreciable adverse effect, preferably such timing between such deposits also does not vary over a page of color printing by greater than approximately twenty-five percent. Nevertheless, it is believed that the invented color variation control method and apparatus may be somewhat more tolerant of juxtaposed black and color dot deposition timing--especially when, as is preferred, black ink dots are deposited before horizontally adjacent color dots are deposited--and that such timing may vary over a page of color printing by as much as 50% or more without undesirably noticeable color banding.

Industrial Applicability

It may be seen then that the invented method significantly reduces undesirable visible color banding, or color variations, that otherwise would compromise color print consistency and overall print quality in liquid ink-jet printing. Black-to-color ink bleeding is not eliminated, but its adverse effects are minimized by printing horizontally adjacent black and color ink drops wherever they appear on a page in that order and with consistent, and preferably constant, timing therebetween. Thus, a two-pen ink-jet printer having a black pen and a color pen may be used to lay down vertically extensive tinted color patterns without visible artifacts that otherwise would result from the reverse ordered color-then-black printing or the disparate number of ink jets available for firing in the two pens. The high-quality color tint palette range is thus extended with minimum printer throughput reduction.

While the present invention has been shown and described with reference to the foregoing operational principles and preferred method, it will be apparent to those skilled in the art that other changes in form and detail may be made therein without departing from the spirit and scope of the invention as defined in the appended claims.

Claims

1. For use with a plural-pen ink-jet printing method whereby color and black ink dots are printed horizontally adjacent one another and the printer's black pen has more ink jets than has the color pen, the improvement comprising: firing selected ones of substantially all vertically adjacent ink jets of the color pen (20) during any one given pass of the printhead, with the vertical span of selected color ink jets defining a color swath height, and firing selected ones of a selected group of vertically adjacent ink jets of the black pen (18) during any other given pass of the printhead, with the vertical span of black ink jets in said selected group defining a black swath height that is approximately equal to such defined color swath height.

2. The improvement of claim 1, wherein such defined black swath height does not vary from such defined color swath height over a page of color printing by greater than approximately twenty-five percent.

3. The improvement of claim 2, wherein said firing of said selected ink jets of the black pen (18) is performed before said firing of said selected ink jets of the color pen (20).

4. The improvement of claim 1, wherein said firing of said selected ink jets of the black pen (18) is performed before said firing of said selected ink jets of the color pen (20).

5. The improvement of claim 1 which further comprises before either of said firing steps storing ink dot data (12) in a memory connected with the printer and analyzing said stored ink dot data (14) to determine whether any represent differently colored closely adjacent dots along such axis, wherein said firing steps (18, 20) are performed such that any difference between timing of the pen firings to print such adjacent dots is minimized.

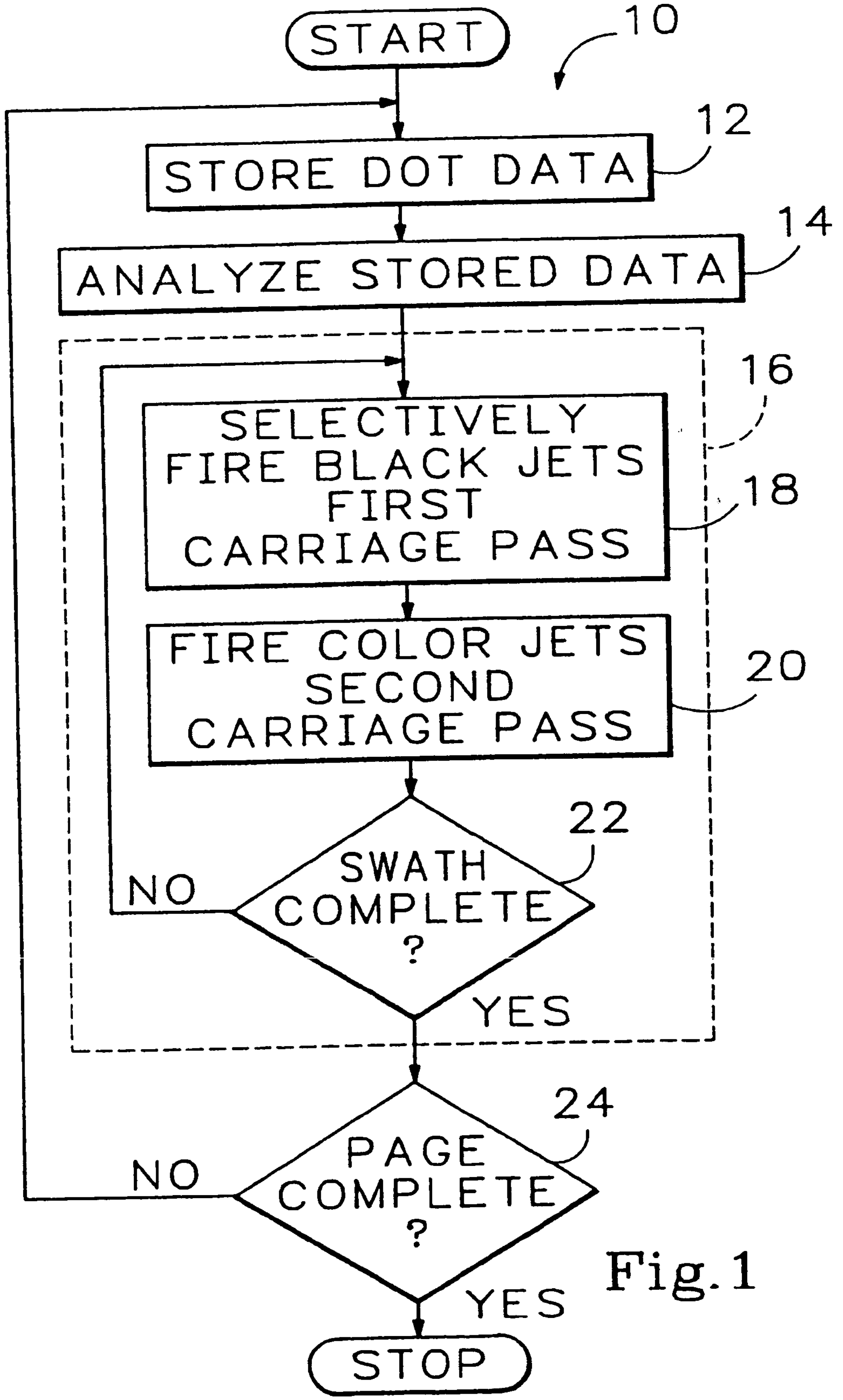
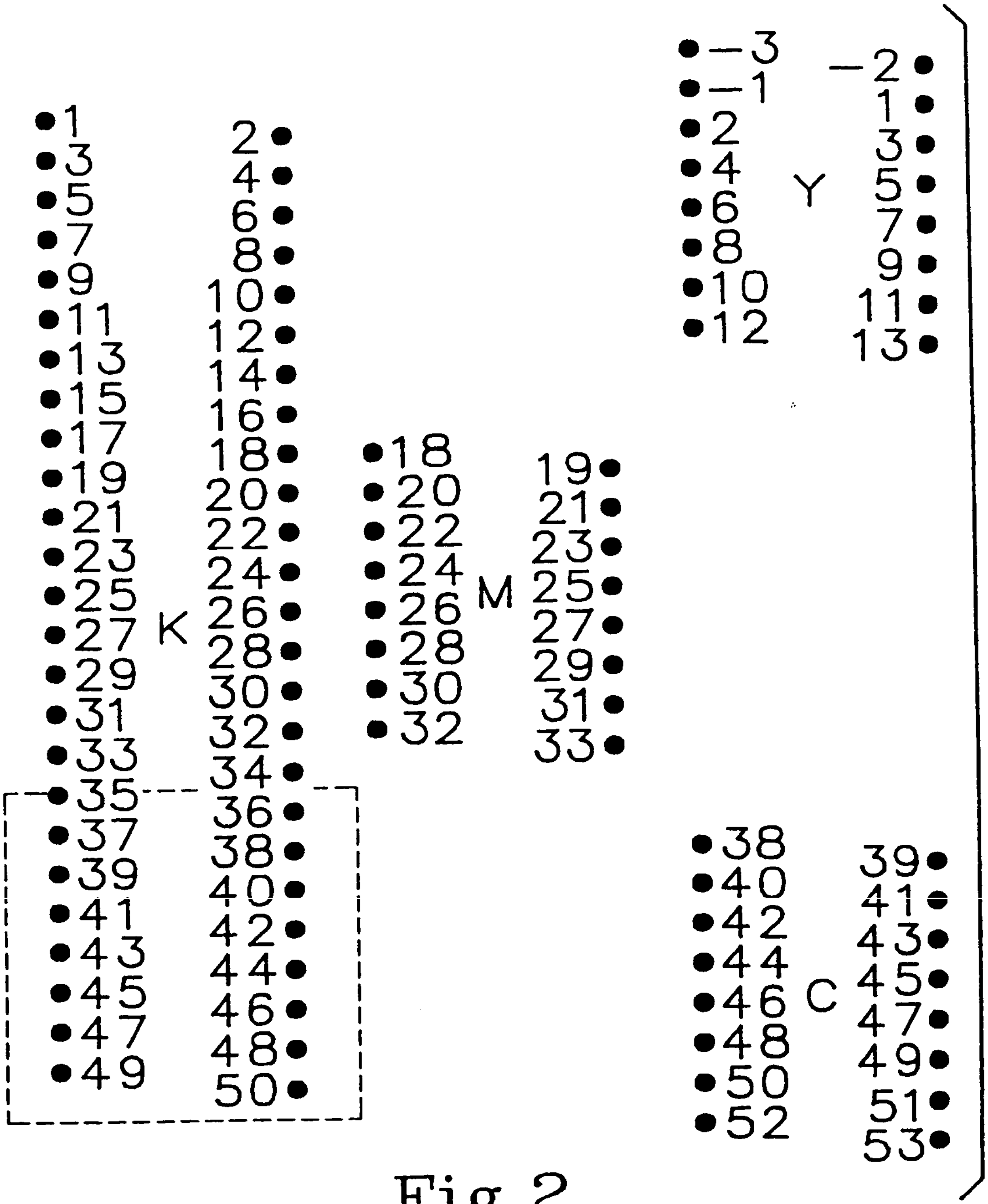

START
10
12
STORE DOT DATA
14
ANALYZE STORED DATA
16
SELECTIVELY FIRE BLACK JETS FIRST CARRIAGE PASS
18
FIRE COLOR JETS SECOND CARRIAGE PASS
20
22
SWATH COMPLETE ?
NO
YES
24
PAGE COMPLETE ?
NO
YES
STOP

Fig.1



-3
-2
-1
Y
K
M
C

Fig. 2

European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 93 30 7468

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
X Y	US-A-4 750 009 (YOSHIMURA) * abstract; figures 1-5 * * column 2, line 58 - column 3, line 37 * ---	1,4 2,3,5	H04N1/46
Y A	US-A-5 075 689 (HOISINGTON ET AL.) * abstract; figures 1-4 * * column 3, line 66 - column 4, line 57 * * column 5, line 36 - line 60 * ---	2,3 1,4,5	
Y A	EP-A-0 390 473 (CANON) * abstract; figures 1-14 * ---	5 1-4	
A	DE-A-34 12 531 (OLYMPIA WERKE) * abstract; figures 4,5 * -----	1-5	
			TECHNICAL FIELDS SEARCHED (Int.Cl.5)
			H04N

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	5 January 1994	Kassow, H

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document
T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

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United States Patent [19]

Yoshimura

[11] **Patent Number: 4,750,009**

[45] **Date of Patent: Jun. 7, 1988**

[54] **COLOR INK JET SYSTEM PRINTER CAPABLE OF HIGH DEFINITION PRINTING**

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[73] Assignee: **Sharp Kabushiki Kaisha**, Osaka, Japan

[21] Appl. No.: **860,868**

[22] Filed: **May 8, 1986**

[30] **Foreign Application Priority Data**

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[51] **Int. Cl.⁴** **G01D 15/18**

[52] **U.S. Cl.** .... **346/140 R**; 400/126

[58] **Field of Search** 346/140; 400/126

[56] **References Cited**

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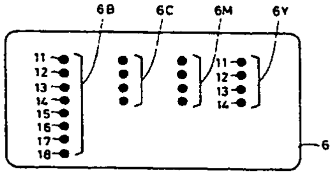
Primary Examiner—Joseph W. Hartary

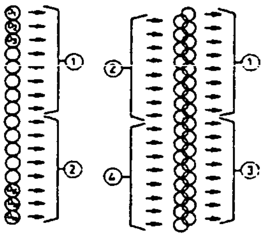
Attorney, Agent, or Firm—Birch, Stewart, Kolasch, & Birch

[57] **ABSTRACT**

An ink jet system printer has a printer head on which a plurality of orifice groups are provided in the main scanning direction of the printer head to correspond to various color inks, the orifices in each group being spaced by a specified distance away from one another in the sub-scanning direction. One of the plurality of the orifice groups consists of a larger number of orifices than the rest and all the orifices in the larger group are vertically aligned with the specified space therebetween. For character printing, the larger orifice groups is selected so that characters of higher definition are printed out at a higher speed. Thus, the ink jet system printer can be used for multiple purposes such as color figure printing and character printing.

2 Claims, 3 Drawing Sheets





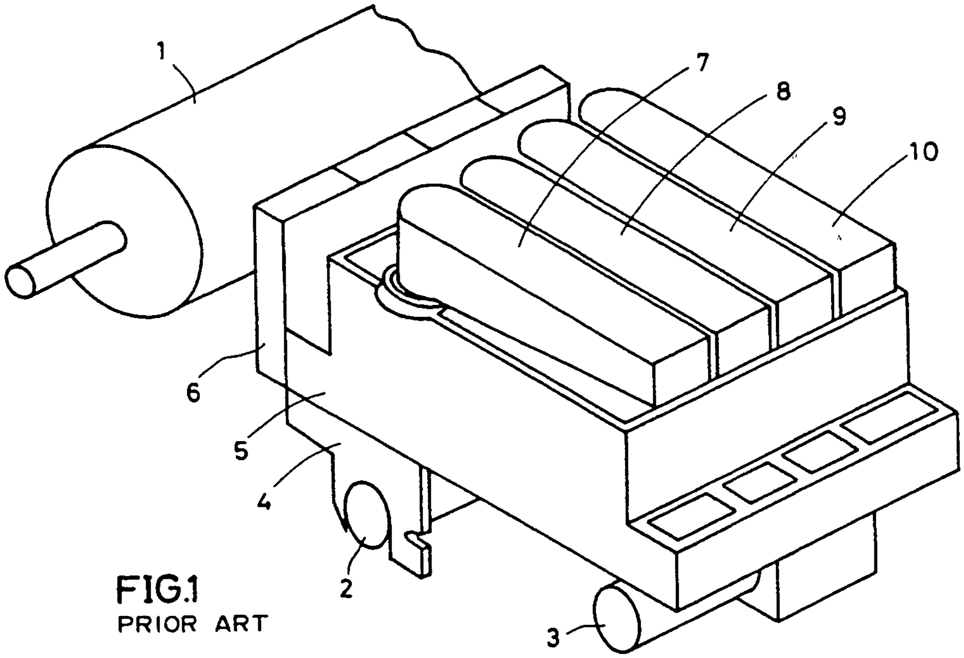


FIG.1
PRIOR ART

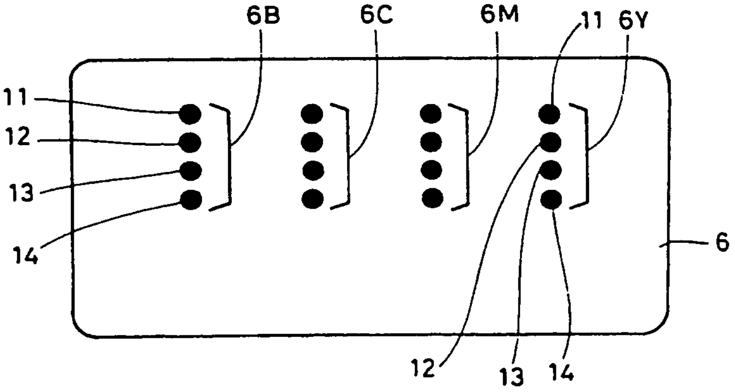


FIG.2 PRIOR ART

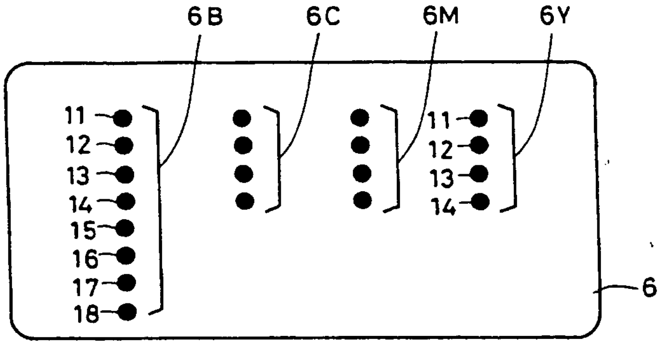


FIG.3

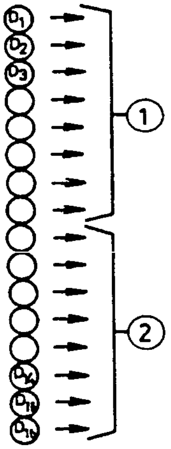


FIG.4(A)

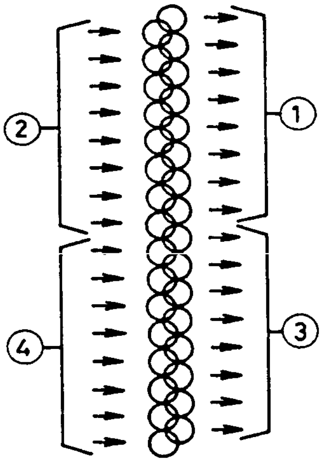


FIG.4(B)

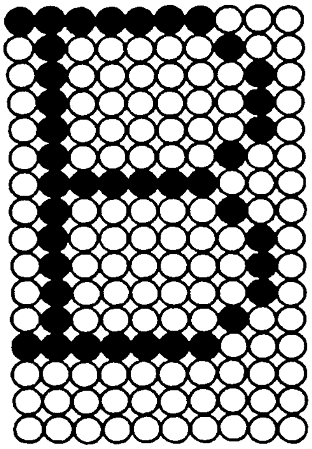


FIG.5(A)

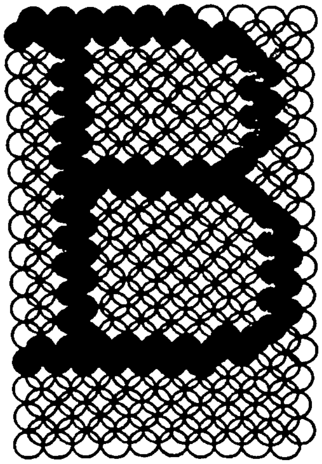


FIG.5(B)

COLOR INK JET SYSTEM PRINTER CAPABLE OF HIGH DEFINITION PRINTING

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a color printer which sprays ink of various colors such as yellow, magenta, cyan and black onto the recording medium in order to make color print-outs.

2. Description of the Prior Art

For printing out figures and characters in multiple colors, an on-demand ink jet printer is conventionally used which prints out figures and characters in color by a mixture of cyan, magenta, yellow and/or black inks loaded on the printer.

FIG. 1 shows the construction of such conventional on-demand ink jet printer. As shown, the printer has slide shafts **2** and **3** mounted parallel to each other in front of a platen **1**. A carriage **4** is supported by the slide shafts **2** and **3** so as to be horizontally movable along the platen **1**.

The carriage **4** is driven by a pulse motor (not shown) which is connected with the carriage **4** through wire. The carriage **4** contains an ink tank **5** and moves rightward for printing operation.

The ink tank **5** is provided with a printer head **6** on the side facing the platen **1**. Four ink cartridges **7**, **8**, **9** and **10** of different color inks are inserted in the ink tank The cartridges **7**, **8** and **9** are for the three primary color inks; yellow, magenta and cyan, and the cartridge **10** is for black ink. The three primary color inks are mixed as necessary on the recording medium in printing out picture elements of multiple colors.

FIG. 2 is a front view of the printer head **6**.

Four orifice groups **6Y**, **6M**, **6C** and **6B** are horizontally arranged on the printer head **6** and each group consists of four vertically aligned orifices **11**, **12**, **13** and **14**. From right to left in the printing direction, the orifice groups **6Y**, **6M**, **6C** and **6B** are for yellow, magenta, cyan and black inks, respectively. The orifices **11**, **12**, **13** and **14** in each group correspond to four vertical recording dots for a picture element. The four orifice groups are horizontally spaced from one another by eight-dot equivalent distance. Each of the four orifices **11**, **12**, **13** and **14** in each group is aligned on the same line with the corresponding orifices in the other groups.

Although the above conventional color printer is generally used for colored figure printing, it is also demanded as an ordinary printer which prints out characters in black.

That is, the demand for multi-purpose printers which can print out not only color figures but also characters of high definition is growing in recent years.

The printer head of the above conventional color printer is, however, designed for color figure printing with the space of 1/120 inches between the vertical recording dots. Therefore, high speed character printing is not possible with this printer head.

In other words, the conventional color printer is very slow in character printing operation. Besides, the characters printed out are of poor definition. In short, the conventional printer functions poorly as a character printer.

OBJECTS AND SUMMARY OF THE INVENTION

1. Objects of the Invention

Accordingly, the object of the present invention is to provide a multi-purpose ink jet system printer which can print out not only color figures but also characters of high definition at a high speed.

Other objects and further scope of applicability of the present invention will become apparent from the detailed description given hereinafter. It should be understood, however, that the detailed description and specific examples, while indicating preferred embodiments of the invention, are given by way of illustration only; various changes and modifications within the spirit and scope of the invention will become apparent to those skilled in the art from this detailed description.

2. Summary of the Invention

According to an embodiment of the present invention, a plurality of orifice groups are arranged in the mainscanning direction on a printer head, each group corresponding to different color ink. The orifices in each group are aligned at a specified interval in the sub-scanning direction of the printer head. One of the plurality of the orifice groups contains a larger number of orifices than the rest, and the orifices in the large group are all aligned at the same specified interval in the sub-scanning direction. The large orifice group is selected for character printing operation so that characters of high definition can be printed out at a high speed. Thus, the present invention can achieve a multi-purpose ink jet system printer which is suitable for character printing as well as for color figure printing.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be better understood from the detailed description given hereinbelow and the accompanying drawings which are given by way of illustration only, and thus are not limitative of the present invention and wherein:

FIG. 1 is a perspective view of an ink-on-demand type color ink jet system printer;

FIG. 2 is a front view of a conventional printer head included in color ink jet system printer of FIG. 1;

FIG. 3 is a front view of an embodiment of a printer head of the present invention included in the color ink jet system printer of FIG. 1;

FIGS. 4(A) and 4(B) are schematic charts for explaining character printing modes performed by the printer head of FIG. 3; and

FIGS. 5(A) and 5(B) are schematic charts for explaining actual print-outs conducted by the character printing modes of FIGS. 4(A) and 4(B), respectively.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 3 is a front view of an embodiment of a printer head **6** of the present invention. Orifice groups **6Y**, **6M**, **6C** and **6B** for yellow, magenta, cyan and black inks, respectively, are arranged in this order from the right to left (in the main-scanning direction of the printer head **6**). Orifices **11**, **12**, **13** and **14** are vertically aligned in the sub-scanning direction in each group, and correspond to four vertical recording dots for a picture element. Each of the orifices **11**, **12**, **13** and **14** of each group is horizontally aligned on the same line with the corresponding orifices of the other groups.

The orifice group **6B** for black ink consists of the above four orifices **11**, **12**, **13** and **14** and additional four orifices **15**, **16**, **17** and **18** which are aligned with the first four orifices **11**, **12**, **13** and **14**. These eight orifices **11** through **18** are all uniformly spaced.

Using the orifice group **6B** of eight orifices **11** through **18** for character printing, the printer of the present invention can print out characters twice as fast as the conventional printer.

Specific description of the ink tank, ink cartridges and other constructions of the present invention is omitted here because they are the same as shown in FIG. **1**.

FIGS. **4**(A) and **4**(B) indicate the character printing modes performed with the orifices **11** through **18**. In this example, the matrix for characters consists of 16×10 dots. FIG. **4**(A) shows the normal character printing mode in which the printer head **6** reciprocates two times for scanning in the order of ① and ② to print dots D_1 through D_{16}. FIG. **4**(B) shows the character printing mode for higher definition, in which the printer head **6** reciprocates four times for scanning in the order of ①, ②, ③ and ④. After scanning of ① and ③, the recording paper is fed by a half pitch of a dot while the printing timing is also staggered by a half pitch with respect to the main-scanning direction. As a result, dots are printed between dots by the scanning steps of ② and ④.

FIG. **5**(A) is an actual print-out of a character "B" by the printing mode of FIG. **4**(A), and FIG. **5**(B) is another actual print-out of "B" by the printing mode of FIG. **4**(B).

As obvious from the above, characters of high definition can be printed out at a high speed by the printer of the present invention. When the printer of the present invention is to be used for ordinary color figure printing, the orifices **11** through **14** of the orifice groups **6Y**, **6M**, **6C** and **6B** are used.

The invention being thus described, it will be obvious that the same may be varied in many ways. Such variations are not to be regarded as a departure from the spirit and scope of the invention, and all such modifications are intended to be included within the scope of the following claims.

What is claimed is:

1. An ink jet system printer which conducts printing operations through the relative movement of a color ink-jetting printer head and a recording medium, wherein a plurality of orifice groups are provided in the main-scanning direction on the printer head, corresponding to various color ink cartridges loaded in the printer, the orifices in each of said orifice groups being vertically aligned with a specified space therebetween, one of said plurality of orifice groups consisting of a larger number of orifices than the rest, said one of said plurality of orifice groups having each orifice therein linearly aligned such that ink jetted therefrom will produce a longitudinally aligned printed pattern, said one of said plurality of orifice groups being used for charcter printing while the other of said plurality of orifice groups are used for graphic printing, said ink jet system being operable in one of two modes, one mode being an ordinary printing mode and the other mode being a high definition mode, said printing operation during said high definition mode further including means for scanning the printer head four times in order to print said aligned pattern, said means for scanning operating in a scanning direction and means for adjusting the positioning of the medium upon which the pattern is printed after two of said scan times by a half a pitch of one of said printed patterns in a direction generally perpendicular to said scanning direction and means for staggering printing time of said printer head by half a pitch of one of said printed patterns in a direction generally parallel to said scanning direction such that a high definition printed character is obtained.

2. The ink jet system printer as claimed in claim **1**, wherein said larger orifice group is used for black ink jetting.

* * * * *